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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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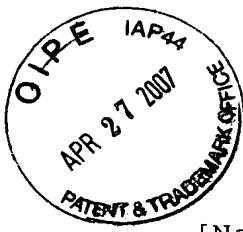
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[Title of the Invention]

PARALLEL PROCESSOR

5 [Claims]

1. A parallel processor that performs parallel processing of one or more basic instructions contained in each of instruction words delimited by instruction delimiting information, said parallel processor characterized by comprising:
  - a plurality of instruction execution units that perform processes corresponding to supplied basic instructions in parallel;
  - an instruction fetch unit that fetches the instruction words one by one in accordance with the instruction delimiting information; and
  - an instruction issue unit that selectively issues each of the basic instructions supplied from the instruction fetch unit to one of the instruction execution units to execute an issued basic instruction.
2. The parallel processor according to claim 1, characterized in that the plurality of instruction execution units all have the same structure.

3. The parallel processor according to claim 1,  
characterized in that:

at least two of the instruction execution units  
have different structures from each other; and  
5 the instruction fetch unit rearranges the basic  
instructions contained in each of the fetched  
instruction words, in accordance with arrangement of the  
plurality of instruction execution units, and then  
supplies the rearranged basic instructions to the  
10 instruction issue unit.

4. The parallel processor according to claim  
1, characterized in that:

at least two of the instruction execution units  
15 have different structures from each other; and  
the instruction issue unit rearranges the basic  
instructions contained in each of the instruction words  
supplied from the instruction fetch unit, in accordance  
with arrangement of the plurality of instruction  
20 execution units, and then supplies the rearranged basic  
instructions to the instruction execution units.

5. The parallel processor according to any one  
of claims 1 to 4, characterized in that:

25 depending on the type of a basic instruction being

currently executed by one of the instruction execution units, the instruction issue unit issues a next basic instruction before the execution of the basic instruction being currently executed is completed.

5

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

10       The present invention generally relates to processors, and, more particularly, to a parallel processor that executes a plurality of basic instructions in parallel.

[0002]

[Prior Art]

15       Generally, in a conventional computer system, a plurality of basic instructions are executed in parallel by pipeline processing, thereby improving its performance. Conventionally, a plurality of basic instructions constitute a fixed-length instruction word, 20 and a very-long instruction word (VLIW) technique is employed as a method for executing a plurality of basic instructions contained in one instruction word in parallel. Also, a super scalar technique may be employed. In accordance with the super scalar technique, basic 25 instructions are executed in parallel depending on the

number of basic instructions contained in each instruction word.

[0003]

FIG. 1 shows the structure of a conventional parallel processor 10. This parallel processor 10 comprises an instruction fetch unit 1 connected to a memory 7, an instruction issue unit 3 connected to the instruction fetch unit 1, instruction execution units EUO to EUn each connected to the instruction issue unit 3, and a register unit 5 connected to each of the instruction execution units EUO to EUn.

[0004]

The instruction fetch unit 1 fetches an instruction word from the memory 7, and supplies the instruction word to the instruction issue unit 3. The instruction issue unit 3 issues the basic instructions contained in the supplied instruction word to the instruction execution units EUO to EUn. If the instruction execution units EUO to EUn are still executing previous basic instructions at this point, the instruction issue unit 3 waits for the end of the execution. When the execution ends, the instruction issue unit 3 supplies the basic instructions to the instruction execution units EUO to EUn.

25 [0005]

The instruction execution units EU0 to EU<sub>n</sub> execute the basic instructions, and notify the instruction issue unit 3 of the end of the execution. The register unit 5 supplies data to the instruction execution units EU0 to EU<sub>n</sub>, if necessary, and holds the execution results of the instruction execution units EU0 to EU<sub>n</sub>. The externally connected memory 7 stores an instruction word string to be executed in the parallel processor 10. The memory 7 also stores necessary data for the execution units EU0 to EU<sub>n</sub> to execute instructions, and data as the execution results.

[0006]

FIG. 2 shows the formats of instruction words to be supplied to a parallel processor having four instruction execution units EU0 to EU3. As shown in FIG. 2, each instruction word is made up of a basic instruction EI and a do-nothing instruction NOP. If the number of basic instructions contained in one instruction word to be executed in parallel is smaller than the number of the instruction execution units EU0 to EU3, the proportion of do-noting instructions is large.

[0007]

In the conventional parallel processing method of executing a plurality of basic instructions by the

VLIW technique, each instruction word has a fixed length. Therefore, if the number of basic instructions to be executed in parallel is smaller than a predetermined number, do-nothing instructions are added to comply with 5 the predetermined length. Because of that, in a program having a small number of basic instructions in total, the proportion of do-nothing instructions is large, and the amount of instruction code increases accordingly, resulting in problems such as poor usage efficiency of 10 memory, a decrease of the hit ratio of cache memory, and an increase of the load on the instruction fetch mechanism.

[0008]

With the super scalar technique, there is also 15 a problem that a large-scale circuit is needed to increase the number of instructions to be executed in parallel.

[0009]

[Problems to be Solved by the Invention]

20 A general object of the present invention is to provide parallel processors in which the above disadvantages are eliminated.

A more specific object of the present invention is to provide a parallel processor that is 25 capable of performing highly efficient parallel

processing.

[0010]

[Means to Solve the Problems]

To achieve the objects, according to one  
5 aspect of the present invention, there is provided a  
parallel processor that performs parallel processing of  
one or more basic instructions contained in each of  
instruction words delimited by instruction delimiting  
information, the parallel processor comprising:

10 a plurality of instruction execution units that  
perform processes corresponding to the supplied basic  
instructions in parallel;

an instruction fetch unit that fetches the  
instruction words one by one in accordance with the  
15 instruction delimiting information; and

an instruction issue unit that selectively issues  
each of the basic instructions supplied from the  
instruction fetch unit to one of the instruction  
execution units to execute the basic instruction.

20 [0011]

With the parallel processor having the above  
structure, the instruction fetch unit makes each  
instruction word length variable, so that the  
instruction words can be fetched one by one in  
25 accordance with the instruction delimiting information.

Also, the instruction execution units can efficiently execute the instruction words, because each of the basic instructions is selectively issued to a corresponding one of the instruction execution units. In the above 5 configuration, all of the instruction execution units may have the same structure.

[0012]

According to another aspect of the present invention, at least two of the instruction execution 10 units have different structures from each other and the instruction fetch unit may rearrange the basic instructions contained in each of the fetched instruction words, in accordance with arrangement of the plurality of instruction execution units, and then 15 supplies the rearranged basic instructions to the instruction issue unit. According to the configuration, since the basic instructions are supplied to the instruction issue unit in accordance with the arrangement of the plurality of instruction execution 20 units, the basic instructions can be effectively executed in parallel.

[0013]

According to still another aspect of the present invention, at least two of the instruction execution 25 units have different structures from each

other and the instruction issue unit may rearrange the basic instructions contained in each of the instruction words supplied from the instruction fetch unit, in accordance with arrangement of the plurality of 5 instruction execution units, and then supply the rearranged basic instructions to the instruction execution units.

Furthermore, depending on the type of a basic instruction being currently executed by one of the 10 instruction execution units, the instruction issue unit may issue a next basic instruction before the execution of a basic instruction being currently executed is completed.

[0014]

15 [Embodiments of the Invention]

The embodiments of the present invention will be explained in detail below with reference to the accompanying drawings. Among the drawings, the same reference numerals are used to designate the same or 20 corresponding components.

[Embodiment 1]

FIGS. 3 and 6 show parallel processors 20 and 21 in accordance with a first embodiment of the present invention. The parallel processor 20 comprises an 25 instruction fetch unit 46 connected to a memory 12, an

instruction issue unit 72 connected to the instruction fetch unit 46, two instruction execution units EU0 and EU1 having the same structure and connected to the instruction issue unit 72, and a register unit 98  
5 connected to each of the instruction execution units EU0 and EU1. Likewise, the parallel processor 21 comprises an instruction fetch unit 47 connected to a memory 12, an instruction issue unit 73 connected to the instruction fetch unit 47, two instruction execution units EU0 and EU1 having the same structure and connected to the instruction issue unit 73, and a register unit 98 connected to each of the instruction execution units EU0 and EU1.  
10

[0015]

15 It should be noted that, in the following description, the maximum basic instruction length of one instruction word is 2. However, the parallel processor in accordance with the first embodiment should operate in the same manner in a case where the maximum basic  
20 instruction length in one instruction word is 3 or greater.

(Example 1)

FIG. 4 shows the structure of the instruction fetch unit 46 and the instruction issue unit 72. The  
25 instruction fetch unit 46 comprises a fetch program

counter (FPC) 300, adders 324 and 325, an instruction buffer 308, a cutting unit 316, and an execution program counter (EPC) 339.

[0016]

5                 The FPC 300 is connected to the memory 12 and the instruction execution units EU0 and EU1. The adder 324 is connected to the FPC 300. The instruction buffer 308 is connected to the memory 12, and the cutting unit 316 is connected to the instruction buffer 308. The 10 adder 325 is connected to the cutting unit 316, and the EPC 339 is connected to the adder 325 and the register unit 98. The FPC 300 receives a fetch address contained in an instruction word from the memory 12, and the instruction buffer 308 receives fetch data contained in 15 the instruction word from the memory 12. The FPC 300 further receives a branch destination address corresponding to a branch instruction from the instruction execution units EU0 and EU1.

[0017]

20                 On the other hand, the instruction issue unit 72 comprises an instruction register 347, selectors 355 and 356, a control unit 370, and an AND gate 378. Here, the instruction register 347 is connected to the cutting unit 316. The selectors 355 and 356 are both connected 25 to the instruction register 347. The selector 355 is

connected to the instruction execution unit EU0, while the selector 356 is connected to the instruction execution unit EU1. The control unit 370 is connected to the AND gate 378 and the selectors 355 and 356. The AND 5 gate 378 is connected to the instruction execution units EU0 and EU1. In this structure, the instruction execution units EU0 and EU1 transmit execution complete signals EUc0 and EUc1, respectively, to the AND gate 378.

[0018]

10 FIG. 5 shows the formats of instruction words to be supplied to the parallel processors of the first embodiment. Each instruction word is made up of one or more basic instructions EI and at least one of instruction word delimiting fields 0 and 1. The basic 15 instruction word length is either 1 or 2. The upper row of FIG. 5 indicates an instruction word having a basic instruction word length of 2, consisting of a basic instruction word made up of an instruction word delimiting field 0 and a basic instruction EI, and another basic instruction word made up of an instruction word delimiting field 1 and a basic instruction EI. The lower row of FIG. 5 indicates an instruction word having a basic instruction word length of 1, consisting of an instruction word delimiting field 1 and a basic 20 instruction EI.

25

[0019]

The above instruction words are stored in the memory 12 in advance. The adder 324 in the instruction fetch unit 46 of the parallel processor 20 increments 5 the address by a fixed length DISP, so that the instruction words can be fetched from the memory 12 in order. When the cutting unit 316 in the instruction fetch unit 46 fetches the instruction word of the upper row of FIG. 5, for instance, it recognizes the 10 instruction word delimiting field and the following basic instruction EI as one instruction word. The cutting unit 316 then cuts the instruction word from the instruction word string, and stores it in the instruction fetch unit 46. The adder 325 calculates the 15 address corresponding to the basic instruction EI to be executed in accordance with an instruction word length signal SL supplied from the cutting unit 316. The calculated address is temporarily stored in the EPC 339. A return address for rerunning the basic instruction EI 20 that is stored in the EPC 339 is supplied to the register unit 98.

[0020]

Based on the instruction word delimiting fields 0 and 1 contained in the instruction words 25 supplied from the cutting unit 316, the instruction

issue unit 72 recognizes each basic instruction EI, and issues each basic instruction EI selectively to one of the instruction execution units EU0 and EU1 via the selectors 355 and 356. Accordingly, if a basic 5 instruction EI following an instruction word delimiting field 0 is issued to the instruction execution unit EU0, while a basic instruction EI following an instruction word delimiting field 1 is issued to the instruction execution unit EU1. The selectors 355 and 356 are 10 controlled by the control unit 370. When the execution of one instruction word is completed, the corresponding basic instruction EI is supplied to the instruction execution units EU0 and EU1 via the selectors 355 and 356.

15 [0021]

Likewise, in a case where the instruction fetch unit 46 fetches and then supplies the instruction word having the basic instruction word length of 1 to the instruction buffer unit 308, the cutting unit 316 20 cuts the basic instruction EI that follows the instruction word delimiting field 1 from the rest of the instruction word. The instruction register 347 then issues the basic instruction EI to one of the instruction execution units EU0 and EU1.

25 [0022]

The instruction word delimiting fields 0 and 1 are both represented by one bit, but any sort of data can be written in those fields as long as they can function to delimit the instruction words. In this 5 example, the two instruction execution units EU0 and EU1 having the same structure are employed, but it is also possible to employ three or more instruction execution units.

[0023]

10 As described so far, in the parallel processor 20 of this example, the instruction fetch unit 46 fetches instruction words one by one in accordance with the instruction word delimiting fields 0 and 1, so that the length of each of the instruction words can be made 15 variable. The instruction issue unit 72 then issues a basic instruction EI to a corresponding one of the instruction execution units EU0 and EU1. Accordingly, there is no need to include do-nothing instructions NOP in any instruction word, and basic instructions EI can 20 be efficiently included in each instruction word. By executing the basic instructions EI in the instruction words, the parallel processing performance of the parallel processor can be improved.

(Example 2)

25 FIG. 6 shows the structure of a second example

of the parallel processor 21 in accordance with the first embodiment of the present invention. As shown in FIG. 6, the parallel processor 21 has the same structure as the parallel processor 20 shown in FIG. 3, except for 5 a judgment unit 103 that determines whether or not each basic instruction EI supplied to the instruction issue unit 73 has data dependence or control dependence with a basic instruction EI being executed by one of the instruction execution units EU0 and EU1, and whether or 10 not each basic instruction EI shares one resource with another basic instruction EI being executed by one of the instruction execution units EU0 and EU1.

[0024]

The judgment unit 103 compares a destination 15 register number (write register number) defined in a basic instruction EI in execution with a source register number (read register number) defined in a basic instruction EI to be issued to one of the instruction execution units EU0 and EU1. If the destination register 20 number coincides with the source register number, it is confirmed that there is data dependence between the two basic instructions EI. If the destination register number does not coincide with the source register number, it is confirmed that there is no data dependence between 25 the two basic instructions EI, and the operation can

proceed.

[0025]

The judgment unit 103 also determines whether or not the basic instruction EI in execution contains a branch instruction, and whether or not the basic instruction EI has a possibility of starting an irregular process such as a division by 0. If the basic instruction EI in execution contains a branch instruction or has a possibility of an irregular process, 10 there is control dependence between the basic instruction EI in execution and the basic instruction EI to be issued to the instruction execution unit EU0 or EU1. If the basic instruction EI in execution neither contains a branch instruction nor has a possibility of 15 an irregular process, it is confirmed that there is no control dependency between the two basic instructions EI.

Based on the contents of each basic instruction EI, the judgment unit 103 also compares the resource (the instruction execution units EU0 and EU1, 20 for instance) required by the basic instruction EI in execution with the resource required by the basic instruction EI to be issued. If the resource required by the basic instruction EI in execution is the same as the resource required by the basic instruction EI to be 25 issued, there is resource sharing between the two basic

instructions EI. If the resources are different, it is confirmed that there is no resource sharing between the two basic instructions EI.

[0026]

5               If the basic instruction EI to be issued has neither data dependency nor control dependency, and causes no resource sharing with the basic instruction EI being executed by the instruction execution units EU0 and EU1, the instruction issue unit 73 issues the basic  
10 instruction EI to a corresponding one of the instruction execution units EU0 and EU1 before the end of the execution. Here, the instruction issuance by the instruction issue unit 73 and the instruction execution by the instruction execution units EU0 and EU1 are  
15 processed by time-sharing parallel processing.

[0027]

On the other hand, if the basic instruction EI to be issued has data dependency and/or control dependency, and/or causes resource sharing with the basic instruction EI being executed by the instruction execution units EU0 and EU1, the basic instruction EI is issued to a corresponding one of the instruction execution units EU0 and EU1 after the end of the execution.

25               Although the two instruction execution units

EU0 and EU1 having the same structure are employed in this example, it is also possible to employ three or more instruction execution units.

[0028]

5 As described so far, the parallel processor 21 of this example can have the same effects as the parallel processor 20 of Example 1, and efficiently and accurately performs the parallel processing of the basic instructions EI Thus, more reliable operations can be  
10 achieved.

[Second Embodiment]

FIGS. 7, and 12 to 21 show parallel processors 22 to 27 in accordance with a second embodiment of the present invention. Each of the parallel processors 22-27 15 comprises an instruction fetch unit 48-53 connected to a memory 12, an instruction issue unit 74-79 connected to the instruction fetch unit 48-53, instruction execution units LU0, IU0, IU1, FU0, FU1, and BU0 connected to the instruction issue unit 74-79, and a register unit 99 connected to all the instruction execution units LU0, 20 IU0, IU1, FU0, FU1, and BU0.

[0029]

The instruction execution unit LU0 is a load store instruction execution unit that executes a load 25 instruction and a store instruction. After the execution

of these instructions, the instruction execution unit LU0 notifies the instruction issue unit 74-79 of the end of the execution. The instruction execution units IU0 and IU1 are integer arithmetic instruction execution 5 units that execute integer arithmetic instructions. When the execution of the integer arithmetic instructions is completed, the instruction execution units IU0 and IU1 notify the instruction issue unit 74-79 of the end of the execution.

10 [0030]

The instruction execution units FU0 and FU1 are floating-point arithmetic instruction execution units that execute floating-point arithmetic instructions. When the execution of the floating-point 15 arithmetic instructions is completed, the instruction execution units FU0 and FU1 notify the instruction issue unit 74-79 of the end of the execution. The instruction execution unit BU0 is a branch instruction execution unit that executes a branch instruction. When the execution of the branch instruction is completed, the 20 instruction execution unit BU0 notifies the instruction issue unit 74-79 of the end of the execution.

[0031]

In the following examples, the maximum basic 25 instruction word length contained in one instruction

word is 2, but the same effects can be expected in a case where the maximum basic instruction word length is 3 or greater.

(Example 1)

5 FIG. 7 shows the structure of a first example of the parallel processor in accordance with the second embodiment of the present invention. As shown in FIG. 7, the parallel processor 22 comprises a conversion unit 115 in the instruction fetch unit 48. The conversion unit 115 rearranges basic instructions contained in one fetched instruction word in accordance with the structure of the instruction execution units LU0, IU0, IU1, FU0, FU1, and BU0, and then supplies the rearranged basic instructions to the instruction issue unit 74.

10 15 This rearrangement by the conversion unit 115 facilitates the issuance of the basic instructions of the instruction issue unit 74.

[0032]

More specifically, the parallel processor of 20 the present invention is embodied on a printed board or an LSI circuit. The components are arranged on a two-dimensional surface and connected by wires. At this point, the wires might cross each other. However, a printed board and an LSI circuit typically have a 25 plurality of wiring layers, so that any two wires that

might cross each other can be arranged on two different wiring layers. Logically, it is possible to place wires in any desired arrangement. In view of the operation speed of the circuit, however, the above alternate 5 wiring (arranging wires on different wiring layers) requires longer wires, which will decrease the operation speed. Therefore, it is preferable to have less alternate wirings. Shorter wires will facilitate the issuance of the basic instruction of the instruction 10 issue unit 74, and increase the operation speed.

[0033]

FIG. 8 shows the structures of the instruction fetch unit 48 and the instruction issue unit 74 of the parallel processor 22 shown in FIG. 7. The instruction 15 fetch unit 48 and the instruction issue unit 74 have the same structures as the instruction fetch unit 46 and the instruction issue unit 72 shown in FIG. 4, except that the instruction fetch unit 48 includes the conversion unit 115 connected to a cutting unit 317. The 20 instruction execution unit BU0 supplies information, such as a branch destination address corresponding to a branch instruction, to a FPC 301.

[0034]

For simplification of the drawing, only two 25 instruction passages from an instruction register 348 to

the two instruction execution units LU0 and LU1 are shown in FIG. 8. However, it should be understood that there are the other instruction passages to the instruction execution units IU1, FU0, FU1, and BU0, as 5 shown in FIG. 7. Likewise, only two signals LUC and IUC0 to the AND gate 379 is shown, but there should be the other passages to the AND gate 379.

[0035]

The parallel processor 22 of this example 10 operates in the following manner. First, the cutting unit 317 of the instruction fetch unit 48 recognizes a basic instruction up to the instruction word delimiting field 1 as an instruction word, same as in the parallel processor according to the first embodiment and fetches 15 instruction words one by one. The formats 13 of the instruction words to be supplied to the instruction fetch unit 48 are shown in FIG. 9. As shown in FIG. 9, each of the instruction words includes an instruction word delimiting field 0 and/or an instruction word 20 delimiting field 1 indicating delimitation of a basic instruction, and one or two instructions selected from the group consisting of an integer arithmetic instruction II, a floating-point arithmetic instruction FI, a load store instruction LI, and a branch 25 instruction BI.

[0036]

An interface 15 for the instruction execution units LU0, IU0, IU1, FU0, FU1 and BU0, includes effective bits V, information II required for executing 5 an integer arithmetic instruction, information FI required for executing a floating-point arithmetic instruction, information LI required for executing a load store instruction, and information BI required for executing a branch instruction. The interface 15 10 supplies the effective bit V and the information LI from the instruction issue unit 74 to the instruction execution unit LU0, the effective bit V and the information II to the instruction execution units IU0 and IU1, the effective bit V and the information FI to 15 the instruction execution units FU0 and FU1, and the effective bit V and the information BI to the instruction execution unit BU0.

[0037]

When the effective bit V is 0, no basic 20 instruction is issued, and when the effective bit 1, a basic instruction is issued. Each effective bit V is coupled with the information II, FI, LI, or BI, and is then allocated to each corresponding instruction execution unit.

25 As shown in FIG. 9, the instruction word

formats 13 are rearranged and converted into instruction word formats 17 by the conversion unit 115 in the instruction fetch unit 48. The instruction word formats 17 correspond to the instruction execution units LU0,  
5 IU0, IU1, FU0, FU1, and BU0, and are supplied to the instruction register 348 in the instruction issue unit 74. The instruction register 348 issues basic instructions each having the effective bit V of 1 to corresponding instruction execution units. For instance,  
10 when the instruction word on the uppermost row of the instruction word format 17 is supplied to the instruction issue unit 74, the instruction issue unit 74 issues the floating-point arithmetic instruction FI provided with "1" as the effective bit V to the  
15 instruction execution unit FU0, and the branch instruction BI also provided with "1" as the effective bit V to the instruction execution unit BU0.

[0038]

As a result, the instruction execution unit  
20 FU0 executes the floating-point arithmetic instruction FI, and the instruction execution unit BU0 executes the branch instruction BI. In this case, no basic instructions are executed by the other instruction execution units LU0, IU0, IU1, and FU1.

25 FIG. 10 is a circuit diagram of the conversion

unit 115 shown in FIG. 8. As shown in FIG. 10, the conversion unit 115 comprises transmission lines L1 and L2, BI detectors BD1 and BD2, FI detectors FD1 and FD2, II detectors ID1 and ID2, LI detectors LD1 and LD2, 5 buffers 155 to 158, AND gates 163 to 166, 185, and 186, exclusive OR gates 187 to 190 selectors 209 to 212, and OR gates 199 to 202.

[0039]

The transmission line L1 transmits the first 10 basic instruction contained in each instruction word, and the transmission line L2 transmits the second basic instruction contained in each instruction word. The BI detector BD1 is connected to the transmission line L1, and the BI detector BD2 is connected to the transmission 15 line L2. The buffer 155 is connected to the BI detector BD1, and the AND gate 163 is connected to the BI detectors BD1 and BD2. The selector 209 is connected to the transmission lines L1 and L2, the buffer 155, and the AND gate 163. The OR gate 199 is connected to the 20 buffer 155 and the AND gate 163.

[0040]

The FI detector FD1 is connected to the transmission line L1, and the FI detector FD2 is connected to the transmission line L2. The buffer 156 is 25 connected to the FI detector FD1, and the AND gate 164

is connected to the FI detectors FD1 and FD2. The two input terminals of the exclusive OR gate 187 are connected to the input node and the output node, respectively, of the buffer 156. The two input terminals 5 of the exclusive OR gate 188 are connected to the output node of the AND gate 164 and the FI detector FD2, respectively. The AND gate 185 is connected to the two exclusive OR gates 187 and 188. The selector 210 is connected to the transmission lines L1 and L2, the 10 buffer 156, and the AND gate 164. The OR gate 200 is connected to the buffer 156 and the AND gate 164.

[0041]

The II detector ID1 is connected to the transmission line L1, and the II detector ID2 is 15 connected to the transmission line L2. The buffer 157 is connected to the II detector ID1, and the AND gate 165 is connected to the II detectors ID1 and ID2. The two input terminals of the exclusive OR gate 189 are connected to the input node and the output node, 20 respectively, to the buffer 157. The two input terminals of the exclusive OR gate 190 are connected to the output node of the AND gate 165 and the II detector ID2, respectively. The AND gate 186 is connected to the two exclusive OR gates 189 and 190. The selector 211 is 25 connected to the transmission lines L1 and L2, the

buffer 157, and the AND gate 165. The OR gate 201 is connected to the buffer 157 and the AND gate 165.

[0042]

The LI detector LD1 is connected to the  
5 transmission line L1, and the LI detector LD2 is connected to the transmission line L2. The buffer 158 is connected to the LI detector LD1, and the AND gate 166 is connected to the LI detectors LD1 and LD2. The selector 212 is connected to the transmission lines L1  
10 and L2, the buffer 158, and the AND gate 166. The OR gate 202 is connected to the buffer 158 and the AND gate 166.

[0043]

The two BI detectors BD1 and BD2 constitute a  
15 BI detector block 147. The two FI detectors FD1 and FD2 constitute an FI detector block 149. The two II detectors ID1 and ID2 constitute an II detector block 151. The two LI detectors LD1 and LD2 constitute an LI detector block 153.

20 [0044]

In the following, an operation of the conversion unit 115 having the above structure will be described by way of an example case where the instruction word including the basic instructions BI and  
25 FI on the uppermost row of the instruction word formats

13 shown in FIG. 9 is supplied to the conversion unit 115. First, the basic instruction BI is transmitted through the transmission line L1. The BI detector BD1 then detects the basic instruction BI and supplies a 5 detection signal of logic 1 to the buffer 155. At this point, the AND gate 163 outputs a logic 0 signal. In accordance with the detection signal supplied from the buffer 155, the selector 209 selects the first basic instruction BI and outputs the first basic instruction 10 BI, that is, an instruction to be executed by the instruction execution unit BU0, to the instruction issue unit 74. At the same time as the output of the basic instruction BI, in accordance with the detection signal supplied from the buffer 155, the OR gate 199 outputs 15 the effective bit V of logic 1. As the first basic instruction BI is detected, the FI detector FD1, the II detector ID1, and the LI detector LD1 output non-detection signals of logic 0. Accordingly, the selectors 210, 211, and 212 do not select the first basic 20 instruction transmitted through the transmission line L1.

[0045]

Next, the second basic instruction FI in the instruction word is transmitted through the transmission line L2. As in the case of the first basic instruction 25 BI, The FI detector FD2 detects the second basic

instruction FI and supplies a detection signal of logic 1 to the AND gate 164. The AND gate 164 in turn outputs a logic 1 signal. In accordance with the logic 1 signal supplied from the AND gate 164, the selector 210 selects 5 the second basic instruction FI and outputs the second basic instruction FI as an instruction to be executed by the instruction execution unit FU0. At the same time as the output of the basic instruction FI, the OR gate 200 outputs the effective bit V of logic 1 in accordance 10 with the detection signal supplied from the AND gate 164.

[0046]

As the second basic instruction FI is detected, the BI detector BD2, the II detector ID2, and the LI detector LD2 output non-detection signals of logic 0. 15 Accordingly, the selectors 209, 211, and 212 do not select the second basic instruction transmitted through the transmission line L2. Since neither first nor second basic instructions to be executed by the instruction executed units LU0, IU0, IU1, and FU1 are detected, the 20 effective bit V of logic 0 is outputted from each of the OR gates 201 and 202, and the AND gates 185 and 186.

[0047]

In the above described manner, the conversion unit 115 converts the instruction word formats 13 into 25 the instruction word formats 17, as shown in FIG. 9.

FIG. 11 is a circuit diagram of the conversion unit 115 in a case where the maximum basic instruction word length of one instruction word to be supplied from the memory 12 to the instruction fetch unit 48 is 4. As shown in FIG. 11, the structure of the conversion unit 115 in this case is the same as the structure of the conversion unit 115 shown in FIG. 10, except that the number of transmission lines are 4, the number of BI detectors is 4, the number of FI detectors is 4, the number of II detectors is 4, and the number of LI detectors is 4. Also, two selectors 214 and 215 are provided for a basic instruction FI, and two selectors 216 and 217 are provided for a basic instruction II in this case.

15 [0048]

The conversion unit 115 further includes buffers 159 to 162, AND gates 167 to 184, exclusive OR gates 191 to 198, OR gates 203 to 208, and selectors 213 and 218. The four BI detectors BD1 to BD4 constitute a BI detector block 148. The four FI detectors FD1 to FD4 constitute an FI detector block 150. The four II detectors ID1 to ID4 constitute an ID detector block 152. The four LI detectors LD1 to LD4 constitute an LI detector block 154.

25 [0049]

The conversion unit 115 having the above structure operates in the same manner as the conversion unit 115 shown in FIG. 10. In the following, an operation of the conversion unit 115 in a case where an 5 instruction word made up of basic instructions BI, FI, FI, and II is supplied to the conversion unit 115 will be described. First, the first basic instruction BI is transmitted through the transmission line L1. The BI detector BD1 then detects the basic instruction BI and 10 supplies a detection signal of logic 1 to the buffer 159. At this point, each of the AND gates 167 to 169 outputs a logic 0 signal. In accordance with the detection signal supplied from the buffer 159, the selector 213 selects the first basic instruction BI and outputs the 15 first basic instruction BI, that is an instruction to be executed by the instruction execution unit BU0, to the instruction issue unit 74. At the same time as the output of the first basic instruction BI, the OR gates 203 outputs the effective bit V of logic 1 in accordance 20 with the detection signal supplied from the buffer 159. As the first basic instruction BI is detected, the FI detector FD1, the II detector ID1, and the LI detector LD1 output non-detection signal of logic 0. Accordingly, 25 the selectors 214, 216, and 218 do not select the first basic instruction BI transmitted through the

transmission line L1.

[0050]

Next, the second basic instruction FI is transmitted on the transmission line L2. The FI detector 5 FD2 then detects the second basic instruction FI and supplies a detection signal of logic 1 to the AND gate 170. The AND gate 170 in turn outputs a logic 1 signal. In accordance with the logic 1 signal supplied from the AND gate 170, the selector 214 selects the second basic 10 instruction FI and outputs the second basic instruction FI as an instruction to be executed by the instruction execution unit FU0. At the same time as the output of the second basic instruction FI, the OR gate 204 outputs the effective bit V of logic 1 in accordance with the 15 detection signal supplied from the AND gate 170.

[0051]

As the second basic instruction FI is detected, the BI detector BD2, the II detector ID2, and the LI detector LD2 each output a non-detection signal of logic 20 0. Accordingly, the selectors 213, 216, and 218 do not select the second basic instruction FI transmitted through the transmission line L2.

Next, the third basic instruction FI is transmitted through the transmission line L3. The FI 25 detector FD3 then detects the third basic instruction FI

and supplies a detection signal of logic level 1 to the AND gate 171. Since the AND gate 171 has already received a detection signal of logic 1 from the FI detector FD2 at this point, the output of the AND gate 171 is a logic 0 signal. Because of that, the exclusive OR gate 193 outputs a logic 1 signal, and the AND gate 174 also outputs a logic 1 signal. In accordance with the logic 1 signal supplied from the AND gate 174, the selector 215 selects the third basic instruction FI and outputs the third basic instruction FI as an instruction to be executed by the instruction execution unit FU1. At the same time as the output of the third basic instruction FI, the OR gate 205 outputs the effective bit V of logic 1 in accordance with the signal supplied from the AND gate 174.

[0052]

As the third basic instruction FI is detected, the BI detector BD3, the II detector ID3, and the LI detector LD3 each output a non-detection signal of logic 0. Accordingly, the selectors 213, 216, and 218 do not select the third basic instruction FI transmitted through the transmission line L3.

Next, the fourth basic instruction II of the instruction word is transmitted through the transmission line L4. The II detector ID4 then detects the fourth

basic instruction II and supplies a detection signal of logic 1 to the AND gate 178. The AND gate 178 in turn outputs a logic 1 signal. In accordance with the logic 1 signal supplied from the AND gate 178, the selector 216 5 selects the fourth basic instruction II and outputs the fourth basic instruction II as an instruction to be executed by the instruction execution unit IU0. At the same time as the output of the fourth basic instruction II, the OR gate 206 outputs the effective bit V of logic 10 1 in accordance with the signal supplied from the AND gate 178.

[0053]

As described above, in the parallel processor of this example, basic instructions contained in each 15 instruction word supplied to the instruction fetch unit 48 are rearranged in accordance with the arrangement of the instruction execution units, so that the instruction issue unit 74 can smoothly issue the basic instructions to the respective instruction execution units. Thus, the 20 entire operation speed can be increased.

In this example, the instruction fetch unit 48 can also fetch an instruction word containing basic 25 instructions that have already been arranged in accordance with the arrangement of the instruction execution units in advance. In such a case, the basic

instruction are arranged in advance so that the circuit size required for rearranging the basic instructions in the instruction fetch unit 48 can be reduced.

[0054]

5                   More specifically, when there are two  
instructions for the same function, only one of the two  
instructions is employed. For instance, the instruction  
word on the uppermost row and the instruction word on  
the fourth row from the top of the formats 13 in FIG. 9  
10 are rearranged into the same formats in the formats 17.  
In this case, only one of the two instruction words  
should be employed, while the use of the other should be  
inhibited. Alternatively, an instruction word that will  
increase the number of alternate wire routes in the  
15 instruction fetch unit 48 may be inhibited beforehand.  
For instance, the instruction words on the upper most  
row and the fourth row from the top of the formats 13 in  
FIG. 9 have the basic instructions BI and FI in the  
opposite orders. Since the circuit components are  
20 arranged on a two-dimensional surface, one of the two  
basic instructions requires more alternate wire routes  
than the other. Accordingly, the instruction word that  
requires more alternate wire routes should be inhibited  
in advance.  
25                   [0055]

As described so far, the circuit size of the parallel processor 22 can be reduced by restricting in advance the arrangement of basic instruction contained in each instruction word to be supplied to the 5 instruction fetch unit 48.

(Example 2)

FIG. 12 shows the structure of a second example of the parallel processor in accordance with the second embodiment of the present invention. As shown in 10 FIG. 12, the parallel processor 23 of this example has the same structure as the parallel processor 22 of Example 1, except that a conversion unit 116 is included in the instruction issue unit 75. The conversion unit 116 has the same structure and functions as the 15 conversion unit 115 shown in FIGS. 10 and 11.

[0056]

FIG. 13 shows the structures of the instruction fetch unit 49 and the instruction issue unit 75 of the parallel processor 23 shown in FIG. 12. The 20 instruction fetch unit 49 and the instruction issue unit 75 has the same structures as the instruction fetch unit 46 and the instruction issue unit 72 shown in FIG. 4, except that the instruction issue unit 75 includes the 25 conversion unit 116 connected to an instruction register 349. For simplification of the drawing, only the

instruction passages to the two instruction execution units LU0 and IU0 are shown, and the instruction passages to the other instruction execution units IU1, FU0, FU1, and BU0 are omitted in FIG. 13. Also, only two execution complete signals LUC and IUC0 to be supplied to the AND gate 380 are shown, and the other execution complete signals are omitted in FIG. 13.

[0057]

With the parallel processor of this example, 10 basic instructions contained in each instruction word supplied from the instruction register 349 are rearranged by the conversion unit 116 in accordance with the arrangement of the instruction execution units. The rearranged basic instructions are then issued to the 15 corresponding instruction execution units. Thus, the wires can be shortened as a whole, and the operation speed can be increased.

[0058]

Also, the arrangement of basic instruction 20 contained in each instruction word to be supplied to the instruction fetch unit 49 can be restricted in advance in the same manner as in Example 1. Thus, the circuit size of the parallel processor 23 can be reduced.

(Example 3)

25 FIG. 14 shows the structure of a third example

of the parallel processor in accordance with the second embodiment of the present invention. As shown in FIG. 14, the parallel processor 24 has the same structure as the parallel processor 22 of Example 1 shown in FIG. 7, 5 except that the instruction fetch unit 50 includes a first conversion unit 117 and the instruction issue unit 76 includes a second conversion unit 118. The first conversion unit 117 rearranges basic instructions contained in each instruction word in accordance with 10 the arrangement of the instruction execution units. The second conversion unit 118 rearranges basic instructions contained in each instruction word in accordance with the arrangement of the instruction execution units.

[0059]

15 FIG. 15 shows the structures of the instruction fetch unit 50 and the instruction issue unit 76 of the parallel processor unit 24 shown in FIG. 14. The instruction fetch unit 50 and the instruction issue unit 76 have the same structures as the instruction 20 fetch unit 46 and the instruction issue unit 72 shown in FIG. 4, except that the instruction fetch unit 50 further includes the first conversion unit 117 connected to a cutting unit 319 and the instruction issue unit 76 further includes the second conversion unit 118 25 connected to an instruction register 350. For

simplification of the drawing, only the instruction passages from the second conversion unit 118 to the two instruction execution units LU0 and IU0 are shown, and the instruction passages to the other instruction execution units IU1, FU0, FU1, and BU0 are omitted in FIG. 15. Likewise, only two execution complete signals LUC and IUC0 to be supplied to the AND gate 381 are shown, and the other execution complete signals are omitted in FIG. 15.

10 [0060]

The first conversion unit 117 performs "preprocessing" of the rearrangement of basic instructions. The second conversion unit 118 performs "postprocessing" of the rearrangement of basic 15 instructions.

In an actual circuit, the processes performed by the instruction fetch unit 50 and the instruction issue unit 76 are pipelined so as to improve the performance of the parallel processor. Because of that, 20 the difference in processing time between instruction fetch unit 50 and the instruction issue unit 76 should be as small as possible to optimize the pipeline effects. Therefore, the arrangement process is divided into the "preprocessing" and "postprocessing", so that the 25 difference in processing time between the instruction

fetch unit 50 and the instruction issue unit 76 is small.  
[0061]

More specifically, the first conversion unit 117 includes circuits that are the counterparts of the 5 BI detector block 147 or 148, the FI detector block 149 or 150, the II detector block 151 or 152, and the LI detector block 153 or 154 shown in FIGS. 10 and 11. The other circuits shown in FIGS. 10 and 11 are included in the second conversion unit 118.

10 [0062]

With the parallel processor 24 having the above structure, the wires can be shortened as a whole, and the operation speed can be reduced. Also, as in Examples 1 and 2, the circuit size of the parallel 15 processor 24 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 50.

(Example 4)

20 FIG. 16 shows the structure of a fourth example of the parallel processor in accordance with the second embodiment of the present invention. As shown in FIG. 16, the parallel processor 25 has the same structure as the parallel processor 22 of Example 1 25 shown in FIG. 7, except that the instruction fetch unit

51 includes a conversion unit 119 and the instruction issue unit 77 includes a judgment unit 104.

[0063]

FIG. 17 shows the structures of the 5 instruction fetch unit 51 and the instruction issue unit 77 of the parallel processor 25 shown in FIG. 16. The instruction fetch unit 51 and the instruction issue unit 77 have the same structures as the instruction fetch unit 48 and the instruction issue unit 74 shown in FIG. 10, except that the instruction issue unit 77 further includes the judgment unit 104. The judgment unit 104 determines whether or not a basic instruction to be issued has data dependency or control dependency with a supplied basic instruction. The judgment unit 104 also 15 determines whether or not the basic instruction to be issued shares resources with the supplied basic instruction. If the basic instruction to be issued has data dependency or control dependency, or shares resources with the supplied basic instruction, the 20 instruction issue unit 77 issues the basic instruction after the execution complete signals LUC and IUC0 are supplied.

[0064]

For simplification of the drawing, only the 25 instruction passages from an instruction register 351 to

the two instruction execution units LU0 and IU0 are shown, and the other instruction passages to the instruction execution units IU1, FU0, FU1, and BU0 are omitted in FIG. 17. Likewise, only the two execution 5 complete signals LUC and IUC0 are shown as signals to be supplied to the judgment unit 104, but the other execution complete signals are omitted in FIG. 17.

[0065]

10 The structure and operation of the conversion unit 119 are substantially the same as the structure and operation of the conversion unit 15 shown in FIGS. 10 and 11. The structure and operation of the judgment unit 104 are substantially the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

15 By the parallel processor of this example having the above structure, the same effects as obtained by the parallel processor of Example 2 of the first embodiment and the parallel processor of Example 1 of the second embodiment can be obtained. In the parallel 20 processor of this example, the instruction issue unit 77, which includes the judgment unit 104, enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the parallel processor. Also, the instruction fetch unit 51, which 25 includes the conversion unit 119, facilitates the basic

instruction issuance to the instruction execution units by the instruction issue unit 77, thereby increasing the operation speed.

[0066]

5                   As in the foregoing examples, the circuit size of the parallel processor 25 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 51.

10                (Example 5)

FIG. 18 shows the structure of a fifth example of the parallel processor in accordance with the second embodiment of the present invention. As shown in FIG. 18, the parallel processor 26 has the same structure as the 15 parallel processor 25 of Example 4, except that the instruction fetch unit 52 includes no conversion unit and the instruction issue unit 78 further includes a conversion unit 120.

[0067]

20                FIG. 19 shows the structures of the instruction fetch unit 52 and the instruction issue unit 78 of the parallel processor 26 shown in FIG. 18. The instruction fetch unit 52 and the instruction issue unit 78 have the same structures as the instruction fetch 25 unit 49 and the instruction issue unit 75 shown in FIG.

13, except that the instruction issue unit 78 further includes the judgment unit 105 connected between an instruction register 352 and a control unit 375. In accordance with a supplied basic instruction, the 5 judgment unit 105 determines whether or not a basic instruction to be issued has the data dependency\_ or control dependency, and whether or not the basic instruction to be issued will cause resource sharing. The judgment results are reported to the control unit 10 375. If the basic instruction to be issued has the data dependency or control dependency, or causes resource sharing, the issue instruction unit 78 issues the basic instruction after the supply of the execution complete signals LUC and IUC0.

15 [0068]

For simplification of the drawing, only the instruction passages from the instruction register 352 to the two instruction execution units LU0 and IU0 are shown, and the instruction passages to the other 20 instruction execution units are omitted in FIG. 19. Likewise, only the two execution complete signals LUC and IUC0 to be supplied to the judgment unit 105 are shown in FIG. 19.

[0069]

25 The structure and operation of the conversion

unit 120 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11. The structure and operation of the judgment unit 105 are the same as the structure and operation of the judgment unit 5 104 shown in FIG. 16.

The parallel processor of this example having the above structure achieves the same effects as the parallel processor of Example 4. The instruction issue unit 78 including the judgment unit 105 enables accurate 10 and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. Also, the instruction issue unit 78, which further includes the conversion unit 120, facilitates the issuance of basic instructions to the instruction 15 execution units and increases the operation speed.

[0070]

Additionally, the circuit size of the parallel processor 26 may be reduced by restricting in advance the arrangement of basic instructions contained in each 20 instruction word to be supplied to the instruction fetch unit 52, as in the foregoing 35 examples.

(Example 6)

FIG. 20 shows the structure of a sixth example of the parallel processor in accordance with the second 25 embodiment of the present invention. As shown in FIG. 20,

the parallel processor 27 has the same structure as the parallel processor 24 of Example 3 shown in FIG. 14, except that the instruction issue unit 79 further includes a judgment unit 106.

5 [0071]

FIG. 21 shows the structures of the instruction fetch unit 53 and the instruction issue unit 79 of the parallel processor 27 shown in FIG. 20. The instruction fetch unit 53 and the instruction issue unit 10 79 have the same structures as the instruction fetch unit 50 and the instruction issue unit 76 shown in FIG. 15, except that the instruction issue unit 79 further includes the judgment unit 106 connected between an instruction register 353 and a control unit 376. Based 15 on a supplied basic instruction, the judgment unit 106 determines whether or not a basic instruction to be issued has the data dependency or control dependency, or causes resource sharing. The judgment results area reported to the control unit 376. If the basic 20 instruction to be issued has the data dependency or control dependency, or causes resource sharing, the instruction issue unit 79 issues the basic instruction only after the execution complete signals LUC and IUC0 are supplied.

25 [0072]

For simplification of the drawing, only the instruction passages from the instruction register 353 to the two instruction execution units LU0 and IU0 are shown, and the instruction passages to the other 5 instruction execution units IU1, FU0, FU1. , and BU0 are omitted in FIG. 21. Likewise, only the two execution complete signals LUC and IUC0 are shown in FIG. 21.

[0073]

The structures and operations of a first 10 conversion unit 121 and a second conversion unit 122 are the same as the structures and operations of the first conversion unit 117 and the second conversion unit 118. The structure and operation of the judgment unit 106 are the same as the structure and operation of the judgment 15 unit 103 shown in FIG. 6.

The parallel processor 27 of this example having the above structure can achieve both effects of the parallel processor of Example 2 of the first embodiment and the parallel processor of Example 3 of 20 the second embodiment. More specifically, the instruction issue unit 79 including the judgment unit 106 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. Also, the instruction 25 fetch unit 53 including the first conversion unit 121

and the instruction issue unit 79 including the second conversion unit 122 facilitate the issuance of basic instructions from the instruction issue unit 79 to the instruction execution units and increase the operation speed.

5 [0074]

10 Additionally, the circuit size of the parallel processor 27 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 53, as in the foregoing examples.

15 [Third Embodiment]

20 As shown in FIGS. 22 to 27, parallel processors 28 to 33 in accordance with a third embodiment of the present invention each comprises an instruction fetch unit 54-59 connected to the memory 12, an instruction issue unit 80-85 connected to the instruction fetch unit 54-59, instruction execution units LU0, IU0, IU1, FU0, FU11, MU0, MU1, and BU0, and a register unit 100 connected to all the instruction execution units. Here, the instruction execution units MU0 and MU1 are special-purpose arithmetic instruction execution units that execute special-purpose arithmetic instructions. When the execution of special-purpose 25 arithmetic instructions is completed, the instruction

execution units MU0 and MU1 notify the instruction issue unit 80-85 of the complete of the execution.

[0075]

In the following, the parallel processors in  
5 accordance with the third embodiment of the present  
invention will be described by way of a case where the  
maximum basic instruction word length contained in one  
instruction word is 2. It should be understood that the  
same effects can be obtained in a case where the maximum  
10 instruction word length contained in one instruction  
word is equal to or more than 3.

(Example 1)

FIG. 22 shows the structure of a first example  
of the parallel processor in accordance with the third  
15 embodiment of the present invention. As shown in FIG. 22,  
the parallel processor 28 comprises a conversion unit  
123 in the instruction fetch unit 54. The structure and  
the operation of the conversion unit 123 are the same as  
the conversion unit 115 of Example 1 of the second  
20 embodiment. More specifically, the conversion unit 123  
rearranges basic instructions contained in each  
instruction word in accordance with the arrangement of  
the instruction execution units, and then supplies the  
rearranged basic instructions to the instruction issue  
25 unit 80.

[0076]

The parallel processor 28 having the above structure can achieve the same effects as the parallel processor 22 of Example 1 of the second embodiment. In 5 other words, the issuance of basic instructions from the instruction issue unit 80 to the instruction execution units can be facilitated, and the operation speed can be increased.

[0077]

10 Additionally, the circuit size of the parallel processor 28 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction execution units, as in the foregoing examples.

15 (Example 2)

FIG. 23 shows the structure of a second example of the parallel processor in accordance with the third embodiment of the present invention. As shown in FIG. 23, the parallel processor 29 has the same 20 structure as the parallel processor 23 shown in FIG. 12, comprising a conversion unit 124 in the instruction issue unit 81. The structure and operation of the conversion unit 124 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 25 and 11.

[0078]

In the parallel processor 29 of this example, the instruction issue unit 81 issues each basic instruction to the corresponding one of the instruction execution units, only after the conversion unit 124 rearranges the basic instructions, which are contained in each instruction word supplied from the instruction fetch unit 55, in accordance with the arrangement of the instruction execution units. Thus, wires can be shortened as a whole, and the operation speed can be increased. Additionally, the circuit size of the parallel processor 29 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 55, as in the foregoing examples.

(Example 3)

FIG. 24 shows the structure of a third example of the third parallel processor in accordance with the third embodiment of the present invention. As shown in FIG. 24, the parallel processor 30 has substantially the same structure as the parallel processor 24 shown in FIG. 14. The instruction fetch unit 56 includes a first conversion unit 125 that rearranges basic instructions contained in each fetched instruction word in accordance

with the arrangement of the instruction execution units. The instruction issue unit 82 includes a second conversion unit 126 that further rearranges basic instructions contained in each instruction word supplied 5 from the instruction fetch unit 56 in accordance with the arrangement of the instruction execution units.

[0079]

The first conversion unit 125 performs "preprocessing" of rearrangement of basic instructions, 10 and the second conversion unit 126 performs "postprocessing" of basic instructions.

In an actual circuit, the processes in the instruction fetch unit 56 and the instruction issue unit 82 are pipelined in order to improve the performance of 15 the parallel processor. Because of that, the difference in processing time between instruction fetch unit 56 and the instruction issue unit 82 should be as small as possible to optimize the pipeline effects. Therefore, the arrangement process is divided into the 20 "preprocessing" and "postprocessing", so that the difference in processing time between the instruction fetch unit 56 and the instruction issue unit 82 is small.

[0080]

By the parallel processor of this example 25 having the above structure, wires can be shortened as a

whole, and the operation speed can be increased.

Additionally, the circuit size of the parallel processor 30 may be reduced by restricting in advance the arrangement of basic instructions contained in each 5 instruction word to be supplied to the instruction fetch unit 56, as in the foregoing examples.

(Example 4)

FIG. 25 shows the structure of a fourth embodiment of the parallel processor in accordance with 10 the third embodiment of the present invention. As shown in FIG. 25, the parallel processor 31 has the same structure as the parallel processor 25 shown in FIG. 16. The instruction fetch unit 57 includes a conversion unit 127, and the instruction issue unit 83 includes a 15 judgment unit 107.

[0081]

The structure and operation of the conversion unit 127 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11. The 20 structure and operation of the judgment unit 107 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

By the parallel processor of this example having the above structure, the same effects as the 25 parallel processor of Example 4 of the second embodiment

can be obtained. More specifically, the instruction issue unit 83 including the judgment unit 107 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the 5 operation. The instruction fetch unit 57 including the conversion unit 127 facilitates the issuance of basic instructions to the instruction execution units, thereby increasing the operation speed.

[0082]

10            Additionally, the circuit size of the parallel processor 31 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 57, as in the foregoing examples.

15    (Example 5)

FIG. 26 shows the structure of a fifth example of the parallel processor in accordance with the third embodiment of the present invention. As shown in FIG. 26, the parallel processor 32 has the same structure as the 20 parallel processor 26 of Example 5 of the second embodiment shown in FIG. 18. The instruction issue unit 84 includes a conversion unit 128 and a judgment unit 108.

[0083]

25            The structure and operation of the conversion

unit 128 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11. The structure and operation of the judgement unit 108 are the same as the structure and operation of the judgment unit 103.

By the parallel processor of this example having the above structure, the same effects as the parallel processor 26 of Example 5 of the second embodiment can be achieved. More specifically, the 10 instruction issue unit 84 including the judgment unit 108 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. The instruction issue unit 84 further including the conversion unit 128 facilitates 15 the issuance of basic instructions to the instruction execution units, thereby increasing the operation speed.

[0084]

Additionally, the circuit size of the parallel processor 32 may be reduced by restricting in advance 20 the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 58, as in the foregoing examples.

(Example 6)

FIG. 27 shows the structure of a sixth example 25 of the parallel processor in accordance with the third

embodiment of the present invention. As shown in FIG. 27, the parallel processor 33 has the same structure as the parallel processor 27 as shown in FIG. 20.

[0085]

5                   The structures and operations of a first conversion-unit 129 and a second conversion unit 130 are the same as the structures and operations of the first conversion unit 117 and the second conversion unit 118 shown in FIG. 14. The structure and operation of a 10 judgment unit 109 are the same as the structure and operation of the judgment unit 103.

By the parallel processor of this example having the above structure, the same effects as obtained by the parallel processor 27 of Example 6 of the second 15 embodiment can be obtained. More specifically, the instruction issue unit 85 including the judgment unit 109 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. The instruction fetch unit 20 59 including the first conversion unit 129 and the instruction issue unit 85 including the second conversion unit 130 facilitate the issuance of basic instructions from the instruction issue unit 85 to the instruction execution units, thereby increasing the 25 operation speed.

[0086]

Additionally, the circuit size of the parallel processor 33 may be reduced by restricting in advance the arrangement of basic instructions contained in each 5 instruction word to be supplied to the instruction fetch unit 59, as in the foregoing examples.

[Fourth Embodiment]

As shown in FIGS. 28 to 33, a parallel processor 34-39 in accordance with a fourth embodiment 10 of the present invention each comprises an instruction fetch unit 60-65 connected to the memory 12, an instruction issue unit 86-91 connected to the instruction fetch unit 60-65, instruction execution units LU0, LU1, IU0, IU1, FU0, FU1, BU0, and BU1 15 connected to the instruction issue unit 86-91, and a register unit 101 connected to all the instruction execution units. In this embodiment, the instruction execution unit LU1 is a load store instruction execution unit that executes load instructions and store 20 instructions. The instruction execution unit BU1 is a branch instruction execution unit that executes branch instructions. When the execution is completed, the instruction execution unit BU1 notifies the instruction issue unit 86-91 of the end of the execution.

25 [0087]

In the following, the parallel processor in accordance with the fourth embodiment of the present invention will be described by way of examples in which the maximum basic instruction word length contained in each one basic instruction is 4. In FIGS. 28 to 33, the maximum basic instruction word length being 4 is indicated by four arrows from the instruction fetch unit 60-65 to the instruction issue unit 86-91. However, it should be understood that the maximum basic instruction word length in the fourth embodiment is not limited to 4.

(Example 1)

FIG. 28 shows the structure of a first example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 28, the parallel processor 34 comprises a conversion unit 131 in the instruction fetch unit 60. The structure and operation of the conversion unit 131 are the same as the structure and operation of the conversion unit 115 of Example 1 of the second embodiment. More specifically, the conversion unit 131 rearranges basic instructions contained in each fetched instruction word, in accordance with the arrangement of the instruction execution units, and supplies the rearranged basic instructions to the instruction issue unit 86.

25 [0088]

By the parallel processor 34 having the above structure, the same effects as obtained by the parallel processor 22 of Example 1 of the second embodiment can also be obtained.

5 More specifically, the issuance of basic instructions from the instruction issue unit 86 to the instruction execution units can be facilitated, and the operation speed can be increased accordingly.

[0089]

10 Additionally, the circuit size of the parallel processor 34 may be reduced- by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 60, as in the foregoing embodiments.

15 (Example 2)

FIG. 29 shows the structure of a second example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 29, the parallel processor 35 has the same structure as the parallel processor 23 shown in FIG. 12, in that the instruction issue unit 87 includes a conversion unit 132. The structure and operation of the conversion unit 132 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11.

[0090]

In the parallel processor 35 of this example, the instruction issue unit 87 rearranges basic instructions contained in each instruction word supplied 5 to the instruction fetch unit 61, in accordance with the arrangement of the instruction execution unit, and then supplies the rearranged basic instructions to the instruction execution units. Thus, wires can be shortened as a whole, and the operation speed can be 10 increased.

Additionally, the circuit size of the parallel processor 35 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch 15 unit 61, as in the foregoing examples.

(Example 3)

FIG. 30 shows the structure of a third example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 30, 20 the parallel processor 36 has the same structure as the parallel processor 24 shown in FIG. 14. The instruction fetch unit 62 of this parallel processor 36 includes a first conversion unit 133 that rearranges basic instructions contained in each fetched instruction word, 25 in accordance with the arrangement of the instruction

execution units. The instruction issue unit 88 of the parallel processor 36 includes a second conversion unit 134 that further rearranges the basic instructions contained in each instruction word supplied from the 5 instruction fetch unit 62, in accordance with the arrangement of the instruction execution units.

[0091]

The first conversion unit 133 performs "preprocessing" of the rearrangement of basic 10 instructions, and the second conversion unit 134 performs "postprocessing" of the rearrangement of the basic instructions.

To improve the performance of the parallel processor in an actual circuit, the processes in the 15 instruction fetch unit 62 and the instruction issue unit 88 are pipelined. Because of that, the difference in processing time between instruction fetch unit 62 and the instruction issue unit 88 should be as small as possible to optimize the pipeline effects. Therefore, 20 the arrangement process is divided into the "preprocessing" and "postprocessing", so that the difference in processing time between the instruction fetch unit 62 and the instruction issue unit 88 is small.

[0092]

25 By the parallel processor 36 of this example

having the above structure, wires can be shortened as a whole, and the operation speed can be increased.

Additionally, the circuit size of the parallel processor 36 may be reduced by restricting in advance 5 the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 62, as in the foregoing examples.

(Example 4)

FIG. 31 shows the structure of a fourth 10 example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 31, the parallel processor 37 has the same structure as the parallel processor 25 shown in FIG. 16, in that the instruction fetch unit 63 includes a 15 conversion unit 135 and the instruction issue unit 89 includes a judgment unit 110.

[0093]

The structure and operation of the conversion unit 135 are the same as the structure and operation of 20 the conversion unit 115 shown in FIGS. 10 and 11. On the other hand, the structure and operation of the judgment unit 110 are the same as the judgment unit 103 shown in FIG. 6.

By the parallel processor 37 of this example 25 having the above structure, the same effects as obtained

by the parallel processor 25 of Example 4 of the second embodiment can be obtained. More specifically, the instruction issue unit 89 including the judgment unit 110 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. The instruction fetch unit 63 including the conversion unit 135 facilitates the issuance of basic instructions from the instruction issue unit 89 to the instruction execution units, thereby increasing the operation speed.

[0094]

Additionally, the circuit size of the parallel processor 37 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 63, as in the foregoing examples.

(Example 5)

FIG. 32 shows the structure of a fifth example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 32, the parallel processor 38 has the same structure as the parallel processor 26 of Example 5 of the second embodiment shown in FIG. 18, in that the instruction issue unit 90 includes a conversion unit 136 and a judgment unit 111.

[0095]

The structure and operation of the conversion unit 136 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11. On the 5 other hand, the structure and operation of the judgment unit 111 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

By the parallel processor of this example having the above structure, the same effects as obtained 10 by the parallel processor 26 of Example 5 of the second embodiment can be obtained. More specifically, the instruction issue unit 90 including the judgment unit 111 enables accurate and efficient parallel processing of basic instructions, thereby increasing the 15 reliability of the operation. The instruction issue unit 90 further including the conversion unit 136 facilitates the issuance of basic instruction to the instruction execution units, thereby increasing the operation speed.

[0096]

20 Additionally, the circuit size of the parallel processor 38 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 64, as in the foregoing examples.

25 (Example 6)

FIG. 33 shows the structure of a sixth example of the parallel processor in accordance with the fourth embodiment of the present invention. As shown in FIG. 33, the parallel processor 39 has the same structure as the 5 parallel processor 27 shown in FIG. 20.

[0097]

The structures and operations of a first conversion unit 137 and a second conversion unit 138 are the same as the structures and operations of the first 10 conversion unit 117 and the second conversion unit 118 shown in FIG. 14. On the other hand, the structure and operation of the judgment unit 112 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

15 By the parallel processor 39 of this example having the above structure, the same effects as obtained by the parallel processor of Example 6 of the second embodiment can be obtained. More specifically, the instruction issue unit 91 including the judgment unit 20 112 enables accurate and efficient parallel processing of basic instructions, thereby increasing the reliability of the operation. The instruction fetch unit 65 including the first conversion unit 137 and the instruction issue unit 91 further including the second 25 conversion unit 138 facilitate the issuance of basic

instructions from the instruction issue unit 91 to the instruction execution units, thereby increasing the operation speed.

[0098]

5                    Additionally, the circuit size of the parallel processor 39 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 65, as in the foregoing examples.

10                [Fifth Embodiment]

As shown in FIGS. 34 to 39, parallel processors 40 to 45 in accordance with a fifth embodiment of the present invention each comprise an instruction fetch unit 66-71 connected to the memory 12, 15 an instruction issue unit 92-97 connected to the instruction fetch unit 66-71, instruction execution units LU0, LU1, IU0, IU1, FU0, FU1, MU0, MU1, BU0, and BU1, and a register unit 102 connected to all the instruction execution units.

20                [0099]

In the following, the parallel processor in accordance with the fifth embodiment of the present invention will be described by way of examples in which the maximum basic instruction word length contained in 25 each instruction word is 4. In FIGS. 34 to 39, the

maximum basic instruction word length being 4 is indicated by four arrows extending from the instruction issue unit 66-71 to the instruction issue unit 92-97.

It should be understood that the maximum basic  
5 instruction word length is not limited to 4 in this embodiment.

(Example 1)

FIG. 34 shows the structure of a first example of the parallel processor in accordance with the fifth embodiment of the present invention. As shown in FIG. 34, 10 the parallel processor 40 comprises a conversion unit 139 in the instruction fetch unit 66. The structure and operation of the conversion unit 139 are the same as the structure and operation of the conversion unit 115 of Example 1 of the second embodiment of the present invention. 15 The conversion unit 139 rearranges basic instructions contained in each fetched instruction word, in accordance with the arrangement of the instruction execution units, and then supplies the rearranged basic 20 instructions to the instruction issue unit 92.

[0100]

By the parallel processor 40 having the above structure, the same effects as obtained by the parallel processor 22 of Example 1 of the second embodiment can 25 be obtained.

More specifically, the issuance of basic instruction from the instruction issue unit 92 to the instruction execution units can be facilitated, and the operation speed can be increased accordingly.

5 [0101]

Additionally, the circuit size of the parallel processor 40 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch 10 unit 66, as in the foregoing embodiments.

(Example 2)

FIG. 35 shows the structure of a second example of the parallel processor in accordance with the fifth embodiment of the present invention. As shown in 15 FIG. 35, the parallel processor 41 has the same structure as the parallel processor 23 shown in FIG. 12, in that the instruction issue unit 93 includes a conversion unit 140. The structure and operation of the conversion unit 140 are the same as the structure and 20 operation of the conversion unit 115 shown in FIGS. 10 and 11.

[0102]

In the parallel processor 41 of this example, the instruction issue unit 93 rearranges basic 25 instructions contained in each instruction word supplied

from the instruction fetch unit 67, and then supplies the rearranged basic instructions to the instruction execution units. Thus, wires can be shortened as a whole, and the operation speed can be increased.

5                 Additionally, the circuit size of the parallel processor 41 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 67, as in the foregoing examples.

10         (Example 3)

FIG. 36 shows the structure of a third example of the parallel processor in accordance with the fifth embodiment of the present invention. As shown in FIG. 36, the parallel processor 42 of this example has the same 15 structure as the parallel processor 24 shown in FIG. 14. The instruction fetch unit 68 of the parallel processor 42 includes a first conversion unit 141 that rearranges basic instructions contained in each fetched instruction word in accordance with the arrangement of the 20 instruction execution units. The instruction issue unit 94 of the parallel processor 42 includes a second conversion unit 142 that further rearranges basic instructions contained in each instruction word supplied from the instruction fetch unit 68 in accordance with 25 the arrangement of the instruction execution units.

[0103]

The first conversion unit 141 performs "preprocessing" of the rearrangement of basic instructions, and the second conversion unit 142 5 performs "postprocessing" of the rearrangement of the basic instructions.

In order to improve the performance of the parallel processor in an actual circuit, the processes in the instruction fetch unit 68 and the 10 instruction issue unit 94 are pipelined. Because of that, the difference in processing time between instruction fetch unit 68 and the instruction issue unit 94 should be as small as possible to optimize the pipeline effects. Therefore, the arrangement process is divided into the 15 "preprocessing" and "postprocessing", so that the difference in processing time between the instruction fetch unit 68 and the instruction issue unit 94 can be small.

[0104]

20 By the parallel processor 42 of this example having the above structure, wires can be shortened as a whole, and the operation speed can be increased.

Additionally, the circuit size of the parallel processor 42 may be reduced by restricting in advance 25 the arrangement of basic instructions contained in each

instruction word to be supplied to the instruction fetch unit 68, as in the foregoing examples.

(Example 4)

FIG. 37 shows the structure of a fourth 5 example of the parallel processor in accordance with the fifth embodiment of the present invention. As shown in FIG. 37, the parallel processor 43 has the same structure as the parallel processor 25 shown in FIG. 16, in that the instruction fetch unit 69 includes a 10 conversion unit 143 and the instruction issue unit 95 includes a judgment unit 113.

[0105]

The structure and operation of the conversion unit 143 are the same as the structure and operation of 15 the conversion unit 115 shown in FIGS. 10 and 11. On the other hand, the structure and operation of the judgment unit 113 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

By the parallel processor 43 of this example 20 having the above structure, the same effects as obtained by the parallel processor 25 of Example 4 of the second embodiment can be obtained. More specifically, the instruction issue unit 95 including the judgment unit 113 enables accurate and efficient parallel processing 25 of basic instructions, thereby increasing the

reliability of the operation. The instruction fetch unit 69 including the conversion unit 143 facilitates the issuance of basic instructions from the instruction issue unit 95 to the instruction execution units,  
5 thereby increasing the operation speed.

[0106]

Additionally, the circuit size of the parallel processor 43 may be reduced by restricting in advance the arrangement of basic instructions contained in each 10 instruction word to be supplied to the instruction fetch unit 69, as in the foregoing examples.

(Example 5)

FIG. 38 shows the structure of a fifth example of the parallel processor in accordance with the fifth 15 embodiment of the present invention. As shown in FIG. 38, the parallel processor 44 of this example has the same structure as the parallel processor 26 of Example 5 of the second embodiment shown in FIG. 18, in that the instruction issue unit 96 includes a conversion unit 144 20 and a judgment unit 114.

[0107]

The structure and operation of the conversion unit 144 are the same as the structure and operation of the conversion unit 115 shown in FIGS. 10 and 11. On the 25 other hand, the structure and operation of the judgment

unit 114 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

By the parallel processor 44 of this example having the above structure, the same effects as obtained 5 by the parallel processor 26 of Example 5 of the second embodiment can be obtained. More specifically, the instruction issue unit 96 including the judgment unit 114 enables accurate and efficient parallel processing of basic instructions, thereby increasing the 10 reliability of the operation. The instruction issue unit 96 further including the conversion unit 144 facilitates the issuance of basic instructions to the instruction execution units, thereby increasing the operation speed.

[0108]

15            Additionally, the circuit size of the parallel processor 44 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 70, as in the foregoing examples.

20            (Example 6)

FIG. 39 shows the structure of a sixth example of the parallel processor in accordance with the fifth embodiment of the present invention. As shown in FIG. 39, the parallel processor 45 of this example has the same 25 structure as the parallel processor 27 shown in FIG. 20.

The instruction fetch unit 71 includes a first conversion unit 145, and the instruction issue unit 97 includes a second conversion unit 146 and a judgment unit 219.

5 [0109]

The structures and operations of the first conversion unit 145 and the second conversion unit 146 are the same as the structures and operations of the first conversion unit 117 and the second conversion unit 10 118 shown in FIG. 14. On the other hand, the structure and operation of the judgment unit 219 are the same as the structure and operation of the judgment unit 103 shown in FIG. 6.

By the parallel processor 45 of this example 15 having the above structure, the same effects as obtained by the parallel processor 27 of Example 6 of the second embodiment can be obtained. More specifically, the instruction issue unit 97 including the judgment unit 219 enables accurate and efficient parallel processing 20 of basic instructions, thereby increasing the reliability of the operation. The instruction fetch unit 71 including the first conversion unit 145 and the instruction issue unit 97 including the second conversion unit 146 facilitate the issuance of basic 25 instructions from the instruction issue unit 97 to the

instruction execution units, thereby increasing the operation speed.

[0110]

Additionally, the circuit size of the parallel 5 processor 45 may be reduced by restricting in advance the arrangement of basic instructions contained in each instruction word to be supplied to the instruction fetch unit 71, as in the foregoing examples.

Finally, means to solve the problems to be solved 10 by the present inventions is appended below:

(1) A parallel processor that performs parallel processing of one or more basic instructions contained in each of instruction words delimited by instruction delimiting information, said parallel 15 processor characterized by comprising:

a plurality of instruction execution units that perform processes corresponding to supplied basic instructions in parallel;

an instruction fetch unit that fetches the 20 instruction words one by one in accordance with the instruction delimiting information; and

an instruction issue unit that selectively issues each of the basic instructions supplied from the instruction fetch unit to one of the instruction 25 execution units to execute an issued basic instruction.

(2) The parallel processor according to (1), characterized in that the plurality of instruction execution units all have the same structure.

(3) The parallel processor according to (1),  
5 characterized in that:

at least two of the instruction execution units have different structures from each other; and

the instruction fetch unit rearranges the basic instructions contained in each of the fetched  
10 instruction words, in accordance with arrangement of the plurality of instruction execution units, and then supplies the rearranged basic instructions to the instruction issue unit.

(4) The parallel processor according to (1),  
15 characterized in that:

at least two of the instruction execution units have different structures from each other; and

the instruction issue unit rearranges the basic instructions contained in each of the instruction words  
20 supplied from the instruction fetch unit, in accordance with arrangement of the plurality of instruction execution units, and then supplies the rearranged basic instructions to the instruction execution units.

(5) The parallel processor according to (1),  
25 characterized in that:

at least two of the instruction execution units have different structures from each other;

the instruction fetch unit rearranges the basic instructions contained in each of the fetched 5 instruction words, in accordance with arrangement of the instruction execution units, and then supplies the rearranged basic instructions to the instruction issue unit; and

the instruction issue unit further rearranges the 10 basic instructions contained in each of the instruction word supplied from the instruction fetch unit, in accordance with the arrangement of the instruction execution units, and then supplies the rearranged basic instructions the instruction execution units.

15 (6) The parallel processor according to any one of (3) to (5), characterized in that:

at least two of the instruction execution units have different structures from each other; and

the instruction fetch unit fetches an instruction 20 word that contains basic instruction arranged in advance in accordance with the arrangement of the instruction execution units.

According this configuration, since the instruction fetch unit fetches an instruction word 25 containing basic instruction arranged in advance in

accordance with the arrangement of the instruction execution units, the circuit size of the parallel processor can be reduced.

(7). The parallel processor according to any 5 one of (1) to (6), characterized in that,

depending on the type of a basic instruction being currently executed by one of the instruction execution units, the instruction issue unit issues next basic instruction before the execution of the basic

10 instruction being currently executed is completed.

(8). The parallel processor according to (7), characterized in that, if a supplied basic instruction does not have data dependency or control dependency, or does not share resources with a basic instruction being 15 currently executed by one of the instruction execution units, the instruction issue unit issues the supplied basic instruction before the execution of the basic instruction being currently executed is completed.

According to the configuration, parallel 20 processing of the basic instructions can be performed more reliably and effectively.

[0111]

[Advantages of the Invention]

As explained above, according to the present 25 inventions, the instruction fetch unit fetches an

instruction word one by one in accordance with the instruction delimiting information, which makes each instruction word length variable, also the instruction issue unit issues each of the basic instructions 5 contained in the instruction words fetched by the instruction fetch unit to one of the corresponding instruction execution units so that the basic instruction can be contained in the instruction word more effectively and capacity of parallel processing by 10 the parallel processor can be improved.

[0112]

Furthermore, in the above configuration, at least two of the instruction execute units has different configuration from each other, no excessive circuit 15 scale for executing the instruction words is required, and downsize of the parallel processor can be achieved.

In addition, the circuit size of the parallel processor can be reduced and faster operation speed can be achieved when the instruction fetch unit rearranges 20 the basic instructions contained in each of the fetched instruction words, in accordance with arrangement of the instruction execution units, and then supplies the rearranged basic instructions to the instruction issue unit.

25 [0113]

Further, more effective parallel processing can be achieved when, depending on the type of a basic instruction being currently executed, the instruction issue unit issues a next basic instruction before the 5 execution currently executed is completed.

[Brief Description of the Drawings]

FIG. 1 shows the structure of a conventional parallel processor;

10 FIG. 2 shows the formats of instruction words to be supplied to a conventional parallel processor having four instruction execution units;

15 FIG. 3 shows the structure of a first example of a parallel processor in accordance with a first embodiment of the present invention;

FIG. 4 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 3;

20 FIG. 5 shows the formats of instruction words to be supplied to the parallel processor of the first embodiment of the present invention;

FIG. 6 shows the structure of a second example of the parallel processor in accordance with the first embodiment of the present invention;

25 FIG. 7 shows the structure of a first example

of a parallel processor in accordance with a second embodiment of the present invention;

FIG. 8 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 7;

FIG. 9 illustrates basic instruction rearrangement in the parallel processor of the second embodiment of the present invention;

FIG. 10 is a circuit diagram of a conversion unit in the parallel processor shown in FIG. 7;

FIG. 11 is a circuit diagram of the conversion unit in a case where the maximum basic instruction word length is 4;

FIG. 12 shows the structure of a second example of the parallel processor in accordance with the second embodiment of the present invention;

FIG. 13 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 12;

FIG. 14 shows the structure of a third example of the parallel processor in accordance with the second embodiment of the present invention;

FIG. 15 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 14;

FIG. 16 shows the structure of a fourth example of the parallel processor in accordance with the second embodiment of the present invention;

5 FIG. 17 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 16;

FIG. 18 shows the structure of a fifth example of the parallel processor in accordance with the second embodiment of the present invention;

10 FIG. 19 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 18;

FIG. 20 shows the structure of a sixth example of the parallel processor in accordance with the second 15 embodiment of the present invention;

FIG. 21 shows the structures of an instruction fetch unit and an instruction issue unit of the parallel processor shown in FIG. 20;

20 FIG. 22 shows the structure of a first example of a parallel processor in accordance with a third embodiment of the present invention;

FIG. 23 shows the structure of a second example of the parallel processor in accordance with the third embodiment of the present invention;

25 FIG. 24 shows the structure of a third example

of the parallel processor in accordance with the third embodiment of the present invention;

FIG. 25 shows the structure of a fourth example of the parallel processor in accordance with the 5 third embodiment of the present invention;

FIG. 26 shows the structure of a fifth example of the parallel processor in accordance with the third embodiment of the present invention;

FIG. 27 shows the structure of a sixth example 10 of the parallel processor in accordance with the third embodiment of the present invention;

FIG. 28 shows the structure of a first example of a parallel processor in accordance with a fourth embodiment of the present invention;

15 FIG. 29 shows the structure of a second example of the parallel processor in accordance with the fourth embodiment of the present invention;

FIG. 30 shows the structure of a third example 20 of the parallel processor in accordance with the fourth embodiment of the present invention;

FIG. 31 shows the structure of a fourth example of the parallel processor in accordance with the fourth embodiment of the present invention;

FIG. 32 shows the structure of a fifth example 25 of the parallel processor in accordance with the fourth

embodiment of the present invention;

FIG. 33 shows the structure of a sixth example of the parallel processor in accordance with the fourth embodiment of the present invention;

5 FIG. 34 shows the structure of a first example of a parallel processor in accordance with a fifth embodiment of the present invention;

FIG. 35 shows the structure of a second example of the parallel processor in accordance with the 10 fifth embodiment of the present invention;

FIG. 36 shows the structure of a third example of the parallel processor in accordance with the fifth embodiment of the present invention;

15 FIG. 37 shows the structure of a fourth example of the parallel processor in accordance with the fifth embodiment of the present invention;

FIG. 38 shows the structure of a fifth example of the parallel processor in accordance with the fifth embodiment of the present invention; and

20 FIG. 39 shows the structure of a sixth example of the parallel processor in accordance with the fifth embodiment of the present invention.

[Description of the Reference Numbers]

- 1, 46-71 INSTRUCTION FETCH UNIT
- 3, 72-97 INSTRUCTION ISSUE UNIT
- 5, 98-102 REGISTER UNIT
- 5 7, 12 MEMORY
- 10 PARALLEL PROCESSOR
- 13, 17 INSTRUCTION WORD FORMAT
- 15 INTERFACE
- 20-45 PROCESSOR
- 10 103-114, 219 JUDGMENT UNIT
- 115-146 CONVERSION UNIT
- 147, 148 BRANCH INSTRUCTION (BI) DETECTOR BLOCK
- 149, 150 FLOATING-POINT ARITHMETIC INSTRUCTION (FI)  
DETECTOR BLOCK
- 15 151, 152 INTEGER ARITHMETIC INSTRUCTION (II) DETECTOR  
BLOCK
- 153, 154 LOAD STORE INSTRUCTION (LI) DETECTOR BLOCK
- 155-162 BUFFER
- 163-186 AND GATE
- 20 187-198 EXCLUSIVE OR GATE
- 199-208 OR GATE
- 209-218, 355-368 SELECTOR
- 300-306 FETCH PROGRAM COUNTER (FPC)
- 308-314 INSTRUCTION BUFFER
- 25 316-322 CUTTING UNIT

324-337 ADDER  
339-345 EXECUTION PROGRAM COUNTER (EPC)  
347-353 INSTRUCTION REGISTER  
370-376 CONTROL UNIT  
5 378-381 AND GATE  
EU0-EUn, LU0, LU1, IU0, IU1, FU0, FU1, MU0, MU1,  
BU0, BU1 INSTRUCTION EXECUTION UNIT  
BD1-BD4 BRANCH INSTRUCTION (BI) DETECTOR  
FD1-FD4 FLOATING-POINT ARITHMETIC INSTRUCTION (FI)  
10 DETECTOR  
ID1-ID4 INTEGER ARITHMETIC INSTRUCTION (II) DETECTOR  
LD1-LD4 LOAD STORE INSTRUCTION (LI) DETECTOR  
L1-L4 TRANSMISSION LINE